Inspection and Condition Assessment of Steel Hydraulic Structures

Inland Waterways Navigation Conference
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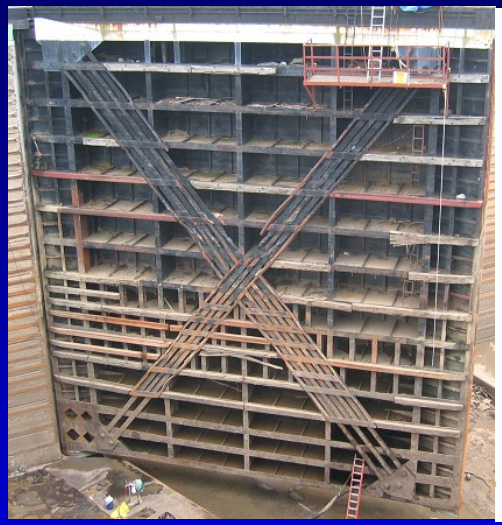

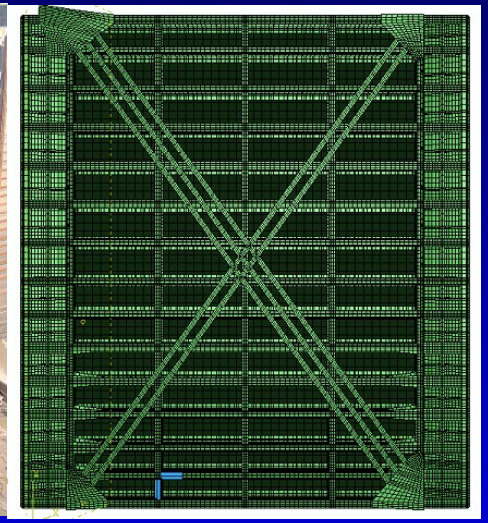

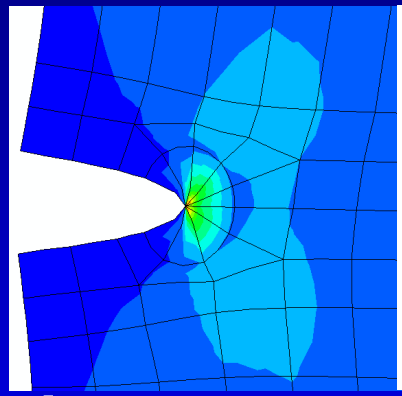

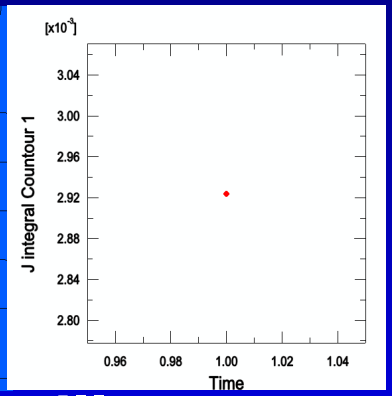

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Presentation Outline

- Problem description
- Capabilities being developed
- Benefits
- Questions

Problem Description (1/2)

- Gates sustain significant number of lockages & repeated loading
- Unsatisfactory performance
  - Fatigue cracking caused by welded connections
  - Poor welding quality
  - Unanticipated structu behavior or loading

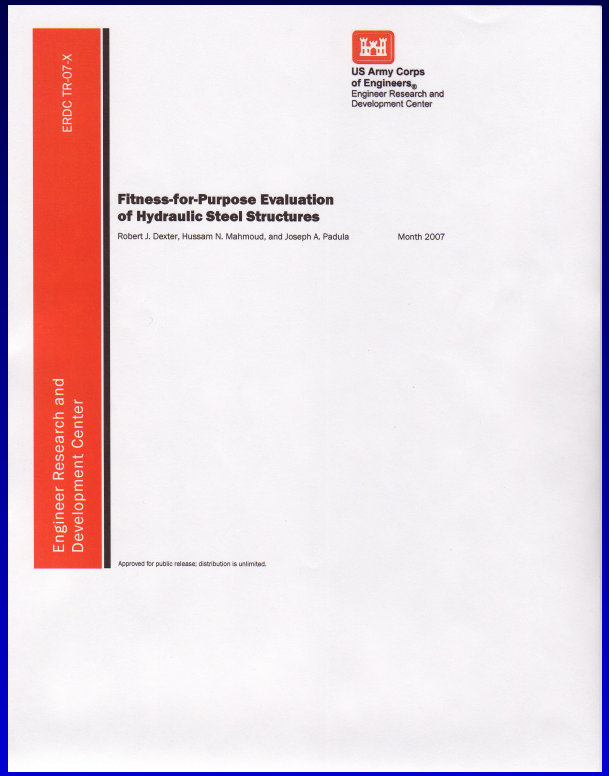
Problem Description (2/2)

- Failures of diagonals on miter gates
  - These appear to be fatigue-induced failures driven by the connection details
  - Current design guidance results in a much larger prestress than may be required

- Stress Intensity Factor (K_I) hand calculations are long and tedious
- Maintenance and repair of f&f failures are a major O&M expenditure

Capabilities Being Developed

- General procedure fitness-for-purpose evaluation of HSS
  - Background on the different types of hydraulic steel structures
  - Typical fatigue cracks that could exist
  - Presents the fracture assessment procedure listed in the BS:7910
  - BS7910 procedures are used to calculate how large a crack-like discontinuity would have to be before it could lead to fracture in a typical steel member


ERDC TR-07-X
US Army Corps of Engineers
Engineer Research and Development Center
Fitness-for-Purpose Evaluation of Hydraulic Steel Structures
Robert J. Dexter, Hussam N. Mahmoud, and Joseph A. Padula
Month 2007
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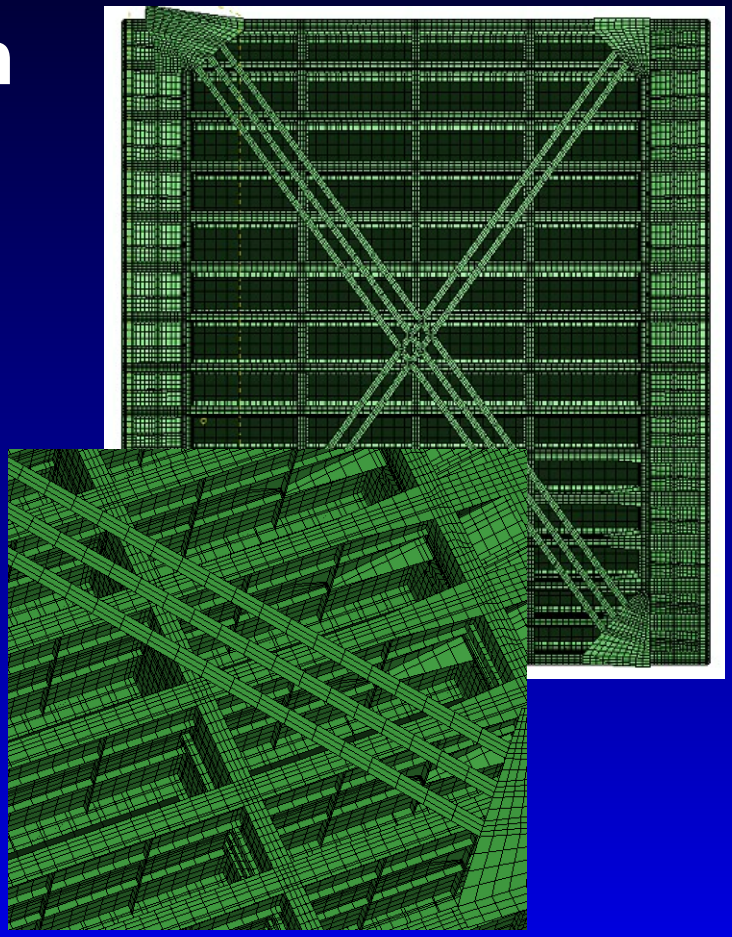
Approved for public release; distribution is unlimited.

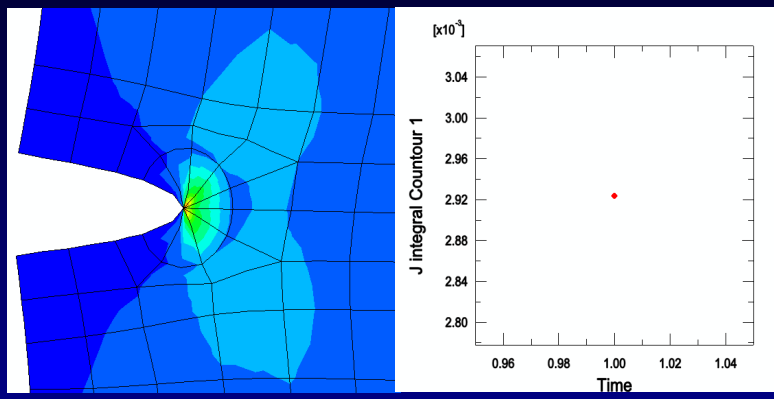
Capabilities Being Developed

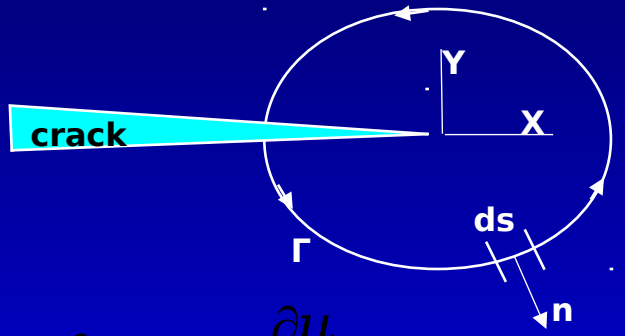
- 3D Finite Element Mesh Generation
  - Actual details are well represented
  - There is no need to simplify details
  - Boundary conditions are easily applied
  - It is possible to study welded connection with special interface elements



Capabilities Being Developed

- **Analytical techniques for employing state-of-the-art capabilities for fracture mechanics analysis using finite element modeling**
  - **Prediction of Stress Intensity Factors (K) – J integral approach**
    - 3D finite element analysis of gates
    - Commercially available nonlinear finite element programs
    - J-integral analysis for fracture analysis
      - Directly compared to elastic or elastic-plastic material properties for assessment





$$J = \int_{\Gamma} w \partial y - T_i \frac{\partial u_i}{\partial x} \partial s$$

$$J = G = \frac{K^2}{[E]}$$

Benefits

- Consistent and systematic guidance for performing a fitness for purpose
- Avoidance of unnecessary repairs
  - cost savings
  - reduced downtime
- 3D FEM – J-integral
  - accurate fracture assessment
  - cost savings through avoidance of unnecessary repairs
  - investigative tool in assessing the actual loads in a member at the time of failure
- Diagonal design criteria and connection details
  - realistic prestress levels
  - elimination of fatigue failures in the diagonal connection

Questions?